CKM Horizontal Input Coupler External Quality Factor Simulations

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4/17/2003

Introduction

The beam-pipe and coupler geometry of the Charge Kaons at the Main Injector (CKM) superconducting radio-frequency (SCRF) cavity has changed since initial input coupler simulations were performed in [1]. Simulations of the external quality factor, Q_{ext}, achieved by the current geometry for various antenna penetration depths are presented here. The results are intended to aid the testing and operational program in the positioning of the antenna penetration depth.

Simulation Considerations & Results

Since initial simulations in [1], the beam-pipe diameter has been increased to 36 mm and the location of the input coupling port center has been relocated to 58.6 mm from the center of the first cavity. Following the notation in [2], the end cell geometry parameters[1] are given in Table I.

Table 1: End Cell Geometry Parameters

r_i : curvature radius at the iris	5.50 mm
r_e : curvature radius at the equator	11.41 mm
a : iris radius	18.00 mm
b : equator radius	47.37 mm
g : cell length	37.20 mm

The end cell with an input coupler was simulated using HFSS[2]. The input coupler antenna tip simulated was a rounded tip with a radius of 3.475 mm which is the same as the inner conductor radius of the 50Ω coaxial coupler which has a 8 mm outer conductor radius. The cavity was polarized with two flats each 1.27 mm on opposite sides of the cavity equator to separate the degenerate TM110-like mode into two separate frequencies. The beam-pipe lengths on each side of the cavity were chosen to ensure the fields in the beam-pipes had sufficiently evanesced up to the ends of the HFSS geometry. Mesh seeding options and symmetry were also utilized to reduce the total number of mesh elements.

A HFSS driven port solution was performed on the geometry for various antenna penetration depths. The penetration depth was defined as the positive distance by which the vertex of the antenna tip penetrated into the beam-pipe wall with the beam-pipe wall taken as the origin. The resultant reflection coefficient data at the input coupler port was post-processed according to the technique developed in [3]; a technique which has been very useful in designing various vertical input couplers for the cavity test stand.

The results for the single-cell Q_{ext} were fit to a natural exponential function and extrapolated to distances further from the beam-pipe wall. The natural exponential function is justified by the natural evanescence of the cavity fields in the hollow coupling port. The results for a 13-cell were then extrapolated by multiplying the single-cell Q_{ext} by 13. This assumes that the 13-cell is operated in a π-mode with equal energy in each cavity; the same logic used in [3]. For more accurate 13-cell extrapolations, any energy unbalance between the end cell and the mid-cells can be taken into account.

The simulation results are shown in Fig 1. Figure 2 shows the HFSS geometry and field solution.

References

[1] C. Deibele T. Berenc, M. Champion, J. Reid, "Simulation of Two Rival Input Coupler Designs for the Superconducting Kaon Separator Cavity", Fermilab RFI Note #011, http://www-rfes.fnal.gov/global/technotes/TN/TN011.pdf

[2] M. McAshan and R. Wanzenberg, "RF Design of a Transverse Mode Cavity for Kaon Separation", Fermilab TM-2144, Batavia, 2001, http://library.fnal.gov/archive/test-tm/2000/fermilab-tm-2144.shtml

[3] T. Berenc and C. Deibele, "Simulation and Measurement Considerations for Resonant Cavity Couplers and Extrapolating Results to Multiple Cells and Varying Conductivities" Fermilab RFNote #005 http://www-rfes.fnal.gov/global/technotes/TN/TN005.pdf

[1] See Fermilab drawing 1610.210-MB-398006, "3.9 GHz SRF Separator End Half Cell".
[2] HFSS (High Frequency Structure Simulator) is written by Ansoft Corp., http://www.ansoft.com

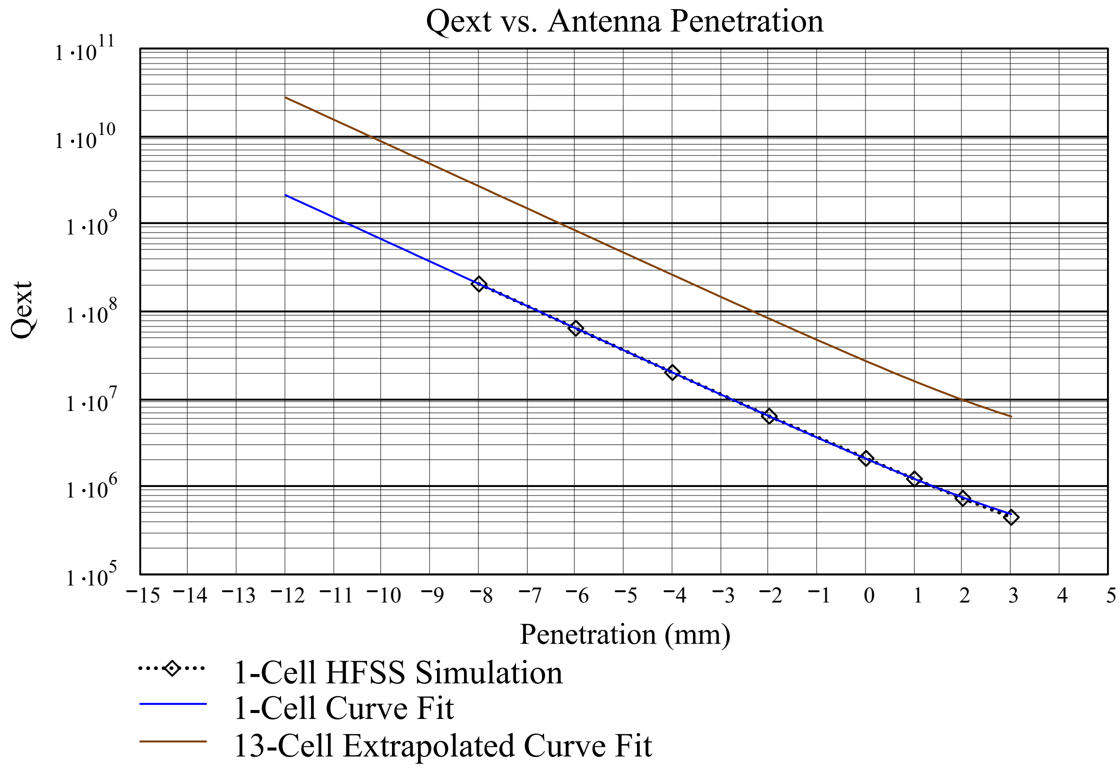

Figure 1: Qext Simulation Results.

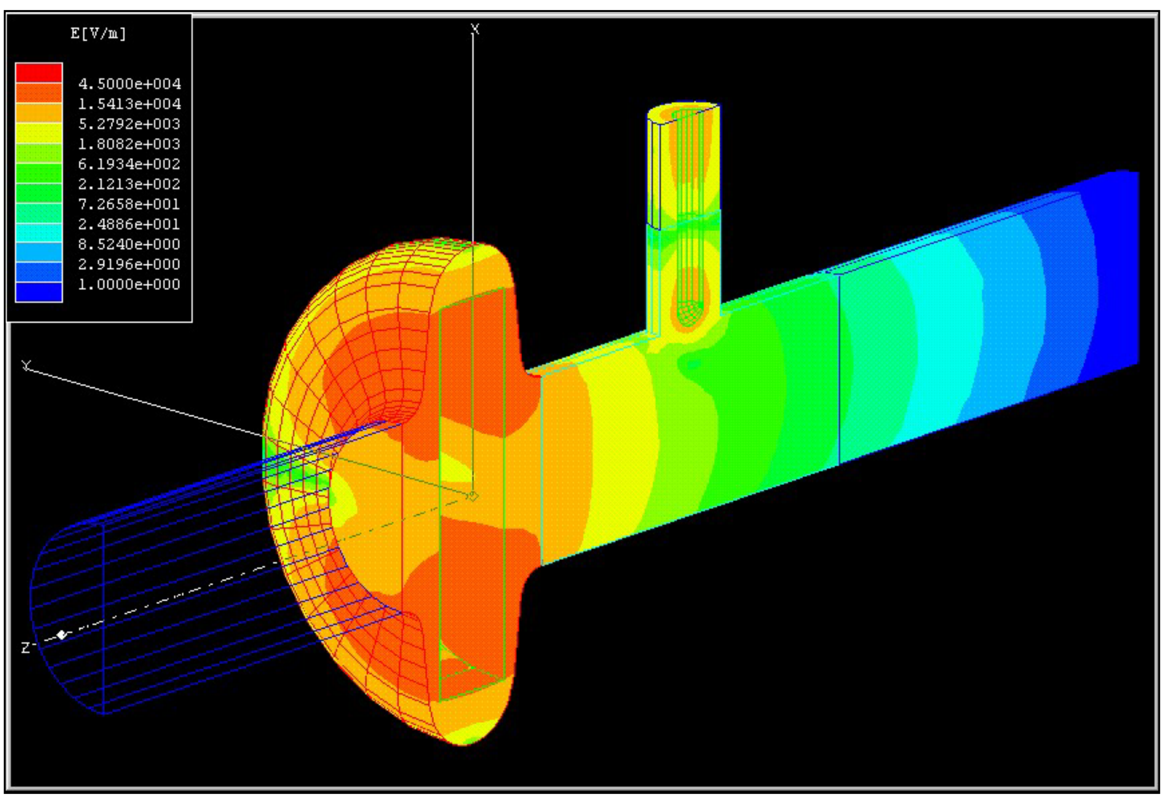

Figure 2: HFSS geometry and electric field magnitude for a driven solution.